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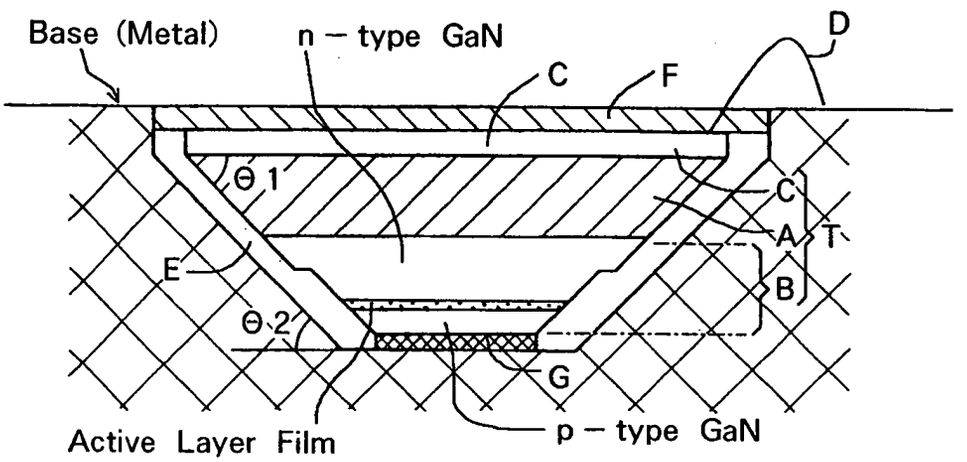
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(54) **LED with a wavelength conversion element for car use**

(57) Wavelength conversion element for car use constituted in the following manner can provide practical LED components for headlights and fog lamps. The element comprises a heat conductive base having a cavity; one or more chips fitted to the cavity bottom, and a wavelength conversion part, which converts emitted light from the chip to visible rays, arranged above the chip. The chip comprises a substrate and a light emitting part constituted by an n-type GaN film, an active layer and a p-type GaN film successively laminated on the substrate. The chip has one straight side in its plan view; an angle formed between the bottom and the side cavity surface is over 0 degree and below 90 degree. The cavity has one straight side in its opening. A ratio of the cavity opening to the totaled areas in plan view of the respective chips, is set less than three.

FIG.1A



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a wavelength conversion element for car use, which utilizes emitted light wavelengths from a light emitting diode (hereinafter referred as "LED") made of compound semiconductors, particularly for a headlight or the like.

2. Brief Description of the Related Art

[0002] An invention disclosed in Japanese laid open patent No.7-99345 is a well known example of wavelength conversion elements.

[0003] As illustrated in a schematic cross-sectional view in FIG.12, an emitting chip 1 of an LED constituted by compound semiconductors is mounted on a cup 2 of a lead frame 3. The LED is sealed by a combination of two resins, the first one is a resin 4 which fills the inside of the cup 2 and the second one is a resin 5 which surrounds the resin 4. A fluorescent material which converts emitted wavelengths from chip 1 into other wavelengths or a wavelength conversion material 6 such as a filter material which absorbs a part of emitted wavelengths is included in the first resin 4, so that luminance and light converging efficiency of the LED are enhanced as being reflected the converted wavelengths by the inner surface of the cup 2.

[0004] If the wavelength conversion element for car use by the present invention is employed as a light source of a light assembly of a car, the LED having a high luminous emittance (lm/mm^2), which determines a required size of an optical portion of the lamp, is desirable. In other words, it is necessary to concentrate luminous flux from the LED on an area as small as possible. However, in a conventional white LED, since excitation light irradiated from the side surface of the chip, an area where there is a fluorescent material corresponds to a light emitting part, namely, the same area as a reflective horn corresponds to the light emitting plane. Consequently, the light emitting part of the LED is large compared with a projected chip area on a plane perpendicular to an optical axis of the LED. In other words the luminous emittance of the LED is lowered to an extent incapable of being employed as the light source of the lamp assembly for car use.

[0005] In the lamp assembly for car use, a light distribution pattern stipulated by the standard is obtained by using reflectors and lenses in front of an emitting plane of the lamp assembly so as to project the emitting plane on an appropriate position.

[0006] In the presently available lamp assemblies, which employ halogen bulbs and discharge lamps, the light distribution pattern is controlled by a combination of two optical systems, a reflector and a projection lens as shown in FIG.13. FIG.14 shows a schematic light distribution pattern (for keep to left countries) of a passing-by lamp beam, which is required to show a sharp contrast (hereinafter referred as "cut-off"). Namely, light does not reach to an upper area than an approximately horizontal line so that light from a headlight of a car does not dazzle a driver of a passing-by car. In the example illustrated in FIG.13, the cut-off is realized by inserting a shield plate between a light source and the projection lens.

[0007] However, the following drawbacks are accompanied, when the optical system illustrated in FIG.13 is employed.

1) The number of required parts is increased because of the complicated optical system.
2) Since a deep space is required for the lamp assembly, it is hard to modify the lamp assembly into a compact one.
3) When the LED is employed as a light source with less luminous than a conventional light source (a halogen bulb or HID), it is hard to obtain a required maximum luminosity for the headlight of the car, since an enlarged light source image is projected by a reflector.
4) Luminosity of the lamp assembly is lost through reflection by the reflector, refraction by the lens and shielding by the shield plate.

[0008] When the conventional white LED is employed and emitted light is controlled by a reflector only so as to attain a compact lamp assembly, portions a little bit lower than the horizontal line, have maximum luminance as illustrated in FIG.16, because a center portion of the LED chip has maximum luminosity as illustrated in FIG.15. Consequently, the required sharp cut-off can not be realized by the conventional white LED.

[0009] Recent technical innovations make a GaN type blue LED available by utilizing conductive substrates such as SiC, GaN, Si and the like. When the conductive substrate is applied to the blue LED for the lamp assembly for car use, one surface of the substrate is connected to a cavity of a base by a conductive adhesive and other surface is electrically

connected to a lead frame via a wire made of Au or the like, which extends from an electrode arranged in the center of the other surface. Since the above-mentioned extending wire made of Au or the like is projected ahead together with a light emitting surface of the light source of the light assembly for car use, a good light distributing pattern can not be obtained.

SUMMARY OF THE INVENTION

[0010] The present invention is carried out in view of the above-mentioned problems in order to obtain a wavelength conversion element for car use, which can be provided as a practically employable part for LED lamps, LED fog lamps and the like.

[0011] The above-mentioned problems are solved by the invention as claimed. Accordingly, a wavelength conversion element for car use comprises: a heat conductive base having a cavity; one or more chips fitted to the cavity; and a wavelength conversion part, which converts a portion of or the total emitted light from the chips, to visible rays, arranged above the chip; wherein: the chip is light emitting semiconductor and comprises at least one active layer which can emit UV or blue light; the chip has at least one straight side in its plan view; an angle $\ominus_2$ formed between the bottom and the side surface of the cavity is more than 0°and less than 90°; the cavity has at least one straight side in its opening; and a ratio of the opening of the cavity to the total of areas of the respective chips in the plan view, is set less than three.

[0012] In a further embodiment a light extracting part having a refractive index between that of the substrate and that of the wavelength conversion part, is formed at the opening side of the cavity.

[0013] Additionally the base can have the cavity has at least one straight side.

[0014] According to another embodiment a shape of the chip and a horn shape of the cavity in their plan view are formed in pallarelograms including a square and a rectangle.

[0015] Preferably the length of the chip is different from the width of the chip.

[0016] In a further embodiment of the invention the chip is a junction down type chip including a flip chip type chip; and an electrode arranged on the bottom of the cavity has a high reflective electrode containing either one of Al, Ag, Rh or Pt.

[0017] In another embodiment portions of one or more of the chip, the substrate and the light extracting part are coated with a high reflective film.

[0018] In a further preferred embodiment portions of one or more of the chip, the substrate and the light extracting part are inclined to the opening of the cavity by an acute angle of $\ominus_1$; inert gas is filled around the chip; and the wavelength conversion part is formed at the opening side of the cavity.

[0019] A thickness d of the light extracting part is determined by the following equation: $d = [(\lambda/4) + m(\lambda/2)]/n$ (λ: a wavelength of the emitted light, n: a refractive index of said light extracting part, m: an integer).

[0020] In another embodiment the chip employing a conductive substrate is fitted to the base by a junction down type junction; the electrode arranged on the bottom of the cavity has the high reflective electrode containing either one of Al, Ag, Rh or Pt; and an electrode at the cavity opening side is arranged outside of the center portion of the wavelength conversion element.

[0021] In a further embodiment the chip employing the conductive substrate is fitted to the base by the junction down type junction; the electrode arranged on the bottom of the cavity has the high reflective electrode containing either one of Al, Ag, Rh or Pt; the light extracting part, which employs a conductive material, is formed on the substrate; and an electrode formed on the light extracting part is arranged outside of the center portion of the wavelength conversion element so as to control an effect caused by a projected shadow of a conductive wire which is formed on the electrode formed on the light extracting part.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

FIGs.1A and 1B are enlarged schematic views illustrating a basic constitution of a wavelength conversion element for car use by the present invention. FIG.1A is a cross-sectional view and FIG.1B is a plan view.

FIG.2 is a plan view illustrating symmetric shaped cavities.

FIGs.3A and 3B are schematic views illustrating a constitution of a wavelength conversion element by embodiment 1. FIG.3A is a cross-sectional side view and FIG.3B is a plan view.

FIGs.4A and 4B are schematic views illustrating constitution of a conventional wavelength conversion element in

order to compare with embodiment 1. FIG.4A is a cross-sectional side view and FIG.4B is a plan view.

FIGs.5A and 5B are schematic views illustrating constitution of a wavelength conversion element by embodiment 2 where the side surface of a cavity is formed upright. FIG.5A is a cross-sectional side view and FIG.5B is a plan view.

FIGs.6A and 6B are schematic views illustrating a constitution of a wavelength conversion element by embodiment 2 where the side surface of a cavity is formed inclined. FIG.6A is a cross-sectional side view and FIG.6B is a plan view.

FIGs.7A and 7B are schematic views illustrating a constitution of a wavelength conversion element by embodiment 3 having no light extracting parts. FIG.7A is a cross-sectional side view and FIG.7B is a plan view.

FIGs.8A and 8B are schematic views illustrating a constitution of a wavelength conversion element by embodiment 3 having a light extracting part. FIG.8A is a cross-sectional side view and FIG.BB is a plan view.

FIGs.9A and 9B are schematic views illustrating a constitution of a wavelength conversion element by embodiment 4. FIG.9A is a cross-sectional side view and FIG.9B is a plan view.

FIG.10 is a chart showing a simulated light distributing pattern when 16 wavelength conversion elements by embodiment 4 are employed in a headlight.

FIGs.11A and 11B are schematic views illustrating a constitution of a wavelength conversion element by another embodiment. FIG.11A is a cross-sectional side view and FIG.11B is a plan view.

FIG.12 is a schematic view illustrating a constitution of a conventional LED.

FIG.13 is a schematic view illustrating a constitution of an ordinary headlight optical system.

FIG.14 is a schematic light distribution pattern (for keep to left countries) of a headlight beam during passing-by.

FIG.15 is schematic view illustrating a luminance distribution pattern of an LED having a conventionally formed cavity.

FIG.16 is a schematic view illustrating luminosity distributing pattern, when the LED shown in FIG.15 is employed in a headlight.

FIG.17 is schematic view illustrating a luminance distribution pattern of an LED having a cavity by the present invention.

FIG.18 is a schematic view illustrating luminosity distributing pattern, when the LED shown in FIG.17 is employed in a headlight.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] Before getting into embodiments by the present invention, a basic constitution of the wavelength conversion element by the present invention is explained as referring to FIG.1.

[0024] The present invention proposes constitutions of the wavelength conversion elements (chips) for converging light irradiated from side surfaces of the chips along optical axe of the chips efficiently and constitutions for suppressing shadows of conductive wires made of Au or the like from being projected ahead.

[0025] A chip T is fitted to a bottom surface of a cavity E formed in a heat conductive base such as Cu or the like. Any materials for forming the chip T can be employed, as far as blue light or ultra-violet light emitted from the materials in the chip T is converted into visible light by fluorescent materials in the chip T. For example, the chip T is obtained in the following manner such that a light emitting part B constituted by an n-type GaN film, an active layer and a p-type GaN film successively grown, is formed on a substrate A. In this case, various materials can be employed as the substrate A, as far as the GaN film can be formed thereon. In order to enhance a light emitting efficiency of the chip T, the light emitting part B should be arranged closer to the base than the substrate A, namely a junction down chip arrangement should be selected, so that heat generated from the chip T is efficiently removed. For that purpose, it is

desirable to employ the substrate A having a transparent property against emitted light from the active layer. When GaN compound semiconductors are employed as excitation light sources, SiC and GaN substrates are thought to be optimal as the substrate A, since the present invention also considers a method for fabricating side surfaces of the substrate A so as to converge emitted light along the optical axis of the chip. In the junction down type chip, electrodes are usually arranged on upper and lower surfaces of the chip T, when the substrate A and a layered light extracting part C are made of conductive materials. Alternatively, a flip chip type structure where both p and n electrodes are formed on the same plane, can be employed.

[0026] Any shaped chip is acceptable as far as the chip T includes a straight line in its plan view as illustrated examples □and □in FIG.2. Parallelograms including a square and a rectangle are practical shapes for the chip, when a manufacturing cost of the chip is taken into consideration. Since the light distributing pattern of the headlight shows an elongated shape in the horizontal direction, a rectangular shape is preferable. When conductive substrates made of SiC, GaN and the like are employed as the substrate A, sometimes electrodes are arranged on the upper and lower surfaces of the chip so as to reduce assembling steps of the lamp assembly. If the electrode is arranged at the center area of the upper surface of the chip, a shadow of a connected Au wire D to the upper electrode is projected on the road, so that a good light distributing pattern cannot be obtained. Therefore, when a flip chip type connection is not employed, the upper electrode at an opening side of the cavity E should not be arranged at the center area, but should be arranged at areas as illustrated in FIG.1 so that a shadow of an Au wire D is not projected on the road. When a conductive material is employed in the light extracting part C (which is explained below) together with the conductive substrate A, the upper electrode should not be arranged at the center area of the light extracting part C, but should be arranged at areas where the shadow of the Au wire D is not projected on the road.

[0027] Since light emitted from the side surface of the chip is scarcely utilized for distributed light by the lamp assembly up to now, it is desirable to control the light emitted from the side surface of the chip so as to be utilized effectively when the chip is employed as a wavelength conversion element for car use. The following method is one of the ways to control the light emitted from the side surface of the chip. When the side surface of the wavelength conversion element including the substrate A is coated with Ag, Al, electrode containing highly reflective materials such as an optical thin film etc. or a reflective film, excitation light is converged to a wavelength conversion part F. Hereinafter, an alternative controlling method is described. In view of the fact that GaN and SiC employed as the substrate A have refractive index of more than 2.5, inert gas having a lower refractive index such as N_2 gas is filled around the chip instead of a fluorescent material constituted by a resin or the like so that a difference between two refractive indexes is raised. As a result a critical angle is lowered so that a total reflection is caused more easily. Thus, when a substrate side angle $\ominus_1$ formed between a plane formed by the opening of the cavity E and the side surface of the substrate A is set less than 90°, the cavity E functions as a reflective horn which transmits light toward the substrate A. Taking the function of the reflective horn into consideration, most optimal substrate side angle $\ominus_1$ should be set between 30°to 60°in order to transmit excitation light to the substrate A effectively. When the substrate A is diced with a diamond blade having a inclined plane, an inclined side surface can be formed on the substrate A. In order to enhance light extracting efficiency more, a high reflective electrode G may be formed as a film at the bottom of the light emitting part B after the side surface of the chip A is formed in the inclined state. When the light emitting part B and/or of the light extracting part C are diced so as to have inclined surfaces, as well as the substrate A, light extracting efficiency is enhanced further more.

[0028] In a junction-down type chip, the high reflective electrode G may be formed on a p-type layer consisting of the top layer of the light emitting part B. The high reflective electrode G can be connected to the p-type layer electrically and a reflective rate of a connected portion to the p-type layer is more than 50 %. It usually contains Ag, Pt, Rh and the like. Sometimes the high reflective electrode G may be formed on a soldering material containing either one of In, Ag or Sn, which fixes the chip T to the base, or may be formed on an electrode constituted by an eutectic agent represented by Au/Sn which is formed on the p-type layer. In a non junction-down chip, a translucent Ni/Au electrode and the like is usually employed as a p-type electrode.

[0029] The light extracting part C may be arranged at the opposite side of the substrate A to the light emitting part B so as to extract excitation light from the substrate A in the axial direction efficiently. Any stable material having a refractive index between that of the light emitting part B and that of the wavelength conversion part F, can be employed as the light extracting part C. For example, ITO, ZnO and the like are employable. Since sometimes a light extracting efficiency may be deteriorated by interference, it is desirable to determine a thickness "d" of the layered light extracting part C as follows: $d = [(\lambda/4) + m(\lambda/2)]/n$ (λ: a wavelength of the emitted light, n: a refractive index of the light extracting part C, m: an integer).

[0030] It is necessary to form the wavelength conversion part F around the chip for converting a portion of the emitted light from the chip into other wavelengths so as to obtain white light constituted by transmitted emitted light from the chip and emitted light from the wavelength conversion part F or constituted by emitted light from the wavelength conversion part F. Although any special materials are not specified as the wavelength conversion material, YAG type fluorescent materials are employed when wavelengths of a light source to excite fall into a blue region. When the

wavelengths of the light source fall into a shorter region than the blue region, trichromatic mixed fluorescent materials for UV light are employed as the wavelength conversion material.

[0031] The wavelength conversion part F may be arranged in the whole cavity E or in the upper part of the cavity E as illustrated in FIG.1. One of the methods of arranging the wavelength conversion part F in the upper part of the cavity E is carried out in the following manner. A fluorescent material capable of converting emitted light from the chip is mixed in a resin such as a silicon resin and mixed resin is precipitated on the upper part of the chip T before the mixed resin is cured. Alternatively, a resin containing the fluorescent material may be applied to the upper part of the chip.

[0032] It is necessary to take measures to enhance a luminous emittance of the chip by reducing the size of the cavity E as small as possible without reducing the light extracting rate. The cavity E with any shape is acceptable, as far as the emitted light from the side surfaces of the light emitting part B is transmitted to the wavelength conversion part F. But the opening of the cavity E should have at least one straight side in its plan view. When the area of the opening of the cavity E is less than 3 times of the projected area of the chip T on its plan view, the luminous emittance is enhanced. However it is optimal to set the area of the opening less than 2 times.

[0033] The basic arrangement of the wavelength conversion element constituted by one chip T as the LED is explained to this point, but it is also applicable to a multi-chip constituted by a plurality of the chip.

[0034] An angle $\ominus_2$ formed by the bottom of the cavity E and the side surface of the cavity E can be set any angle between 0□and 90□, as far the size of the opening is set within the above-mentioned conditions. It is desirable to form the side surfaces of the cavity E upright from the viewpoints of a manufacturing cost and reliability.

[0035] The base including the cavity E should have at least one straight side in its plan view so that the chip is not revolved in an undesirable direction when it is attached to the lamp assembly so as to obtain a desired light distributing pattern.

[0036] Hereinafter several embodiments, which are constituted based on the above-mentioned basic arrangement, are explained. The wavelength conversion element for car use by the present invention having a shape as schematically illustrated in FIG.17, shows higher luminosity over the whole chip, which means light flux is concentrated in a small area, when compared with the conventional chip illustrated in FIG.15. Consequently, a more distinctive cut-off is attained by the present invention as illustrated in FIG.18 compared with that of the conventional chip (see FIG.16).

[Embodiment 1]

[0037] The present embodiment is explained as referring to FIGs.3A and 3B.

[0038] FIGs.3A and 3B are schematic views illustrating the constitution of the wavelength conversion element which is applied to the LED lamp for car use. FIG.3A is the cross-sectional side view and FIG.3B is the plan view.

[0039] An LED device constituted by layered GaN films being grown on a SiC substrate is manufactured as a chip T_1. The chip T_1 has an area of 1 mm by 2mm and a height of 0.3mm and emits excitation light with a wavelength of 470nm. The flip chip type junction is selected for the present chip. A silicon resin mixed with a YAG:Ce fluorescent is filled in a cavity E_1 so as to obtain white light, of which color coordinates are as follows: X = 0.31 and Y = 0.32.

[0040] The cavity E_1 of the chip T_1 illustrated in FIGs.3A and 3B by the present invention has a bottom of 1.1mm by 2.1 mm and an angle between the side surface of the cavity and the bottom is formed upright.

[0041] In order to compare performances between the present chip and the conventional chip, the conventional typed chip, in which a resin with the same composition as the above-mentioned chip T_1 is employed. FIGs.4A and 4B are schematic views illustrating the conventional chip. FIG.4A is the cross-sectional side view and FIG.4B is the plan view.

[0042] As illustrated in FIGs.4A and 4B, a cavity Ex of the conventional chip has a circular bottom with a diameter of 3.0mm and a side surface with an inclined angle of 45□.

[0043] Performances of the lamps for car use constituted by the above-mentioned chips are compared. Performance data measured without attaching a lens to the lamp assembly are shown in TAB.1.

TAB.1

	Conventional LED (FIGs.4A, 4B)	Embodiment 1 (FIGs.3A, 3B)
Luminous Flux	36.4 lm	30.5 lm
Area of Cavity Opening	12.6 mm^2	2.3 mm^2
Luminous Emittance	2.89 lm/mm^2	13.3 lm/mm^2

As understood through data in TAB.1, the luminous emittance is improved when the more converging and smaller cavity E_1 is employed, so that embodiment 1 is judged to be an excellent wavelength conversion element for car use.

[Embodiment 2]

[0044] LED devices constituted by layered GaN films being grown on SiC substrates are manufactured as chip T_2 illustrated in FIGs.5A and 5B, and T_3 illustrated in FIGs.6A and 6B. The chips T_2 and T_3 respectively have an area of 1 mm by 1 mm and a height of 0.3mm and emit excitation light with a wavelength of 470nm. The flip chip type junctions are selected for both chips. The side surface of the chip T_2 is formed upright and the whole side surfaces of the chip are inclined 45°in relation to the bottom of the chip T_3. The cavity $E_{\square}$ illustrated in FIGs.5A and 5B has a bottom of 1.1mm by 1.1 mm and the cavity E_3 illustrated in FIGs.6A and 6B has a bottom of 0.5mm by 0.5mm and a cavity opening of 1.1mm by 1. 1mm. A silicon resin mixed with a YAG:Ce fluorescent material is filled in a cavity E_2 of chip T_2 illustrated in FIGs.5A and 5B so as to obtain white light. N_2 gas is filled around the chip T_3 illustrated in FIGs.6A and 6B and a quartz glass plate coated with a solution including the same fluorescent material as the chip T_2, employed as a wavelength conversion part F_1, is applied to the upper portion of the chip T_3 such that the coated side of the quartz glass plate is closely contacted to the chip T_3. A thickness or concentration of the fluorescent material is adjusted so as to obtain color coordinates: X = 0.32 and Y = 0.31 in both chips T_2 and T_3. Performances of the chips T_2 and T_3 are measured without attaching a lens to the lamp assembly and obtained data are shown in TAB.2.

TAB.2

	Upright sided chip (FIGs.5A, 5B)	Inclined sided chip (FIGs.6A, 6B)
Luminous Flux	17.2 lm	21.6 lm
Area of Cavity Opening	1.2 mm^2	1.2 mm^2
Luminous Emittance	14.3 lm/mm^2	18.0 lm/mm^2

Comparing data in TAB.2, it is confirmed that the luminous emittance is improved, when the side surface of the chip T_3 is inclined and N_2 gas is filled around the cavity E_3.

[Embodiment 3]

[0045] LED devices constituted by layered GaN films being grown on SiC substrates are manufactured as chip T_4 illustrated in FIGs.7A and 7B, and T_5 illustrated in FIGs.8A and 8B. The chips T_4 and T_5 respectively have an area of 1 mm by 2mm and a height of 0.3mm and emit excitation light with a wavelength of 470nm. The junction down type junctions are selected for both chips. The side surfaces of the cavities of the chip T_4 and T_5 are formed upright. Both cavities E_4 and E_4 respectively have a bottom of 1.1 mm by 2.1 mm. The light extracting part is not employed in the chip T_4 illustrated in FIGs.7A and 7B. A light extracting part C_1 made of ITO, which also functions as a current diffusing layer, is formed on the chip T_5 illustrated in FIG.8A. A silicon resin mixed with a YAG:Ce fluorescent material is filled in both cavities E_4 and E_4 so as to obtain white light. A thickness or concentration of the fluorescent material is adjusted so as to obtain color coordinates: X = 0.32 and Y = 0.31 in both chips T_4 and T_5. Performances of the chips T_4 and T_5 are measured without attaching a lens to the lamp assembly and obtained data are shown in TAB.3.

TAB.3

	No light extracting part (FIGs.7A, 7B)	With light extracting part (FIGs.8A, 8B)
Luminous Flux	30.2 lm	35.2 lm
Area of Cavity Opening	2.3 mm^2	2.3 mm^2
Luminous Emittance	13.1 lm/mm^2	15.3 lm/mm^2

From data in TAB.3, it is confirmed that the luminous emittance is improved by the light extracting part C_1

[Embodiment 4]

[0046] An LED device constituted by layered GaN films being grown on a SiC substrate is manufactured as chip T_6 illustrated in FIGs.9A and 9B. The chip T_6 has an area of 1 mm by 1 mm and a height of 0.3mm and emit excitation light with a wavelength of 470nm. The junction down type junction is selected for the present chip. The side surface of the cavity of the chip T_6 is formed upright. A cavity E_5 has a bottom of 1.2mm by 1.2mm. The light extracting part is not arranged in the chip T_6. A silicon resin mixed with a YAG:Ce fluorescent material is filled in the cavity E_5 so as to obtain white light. A thickness or concentration of the fluorescent material is adjusted so as to obtain color coordinates:

X = 0.32 and Y = 0.31 in the chips T_6. A Performance of the chip T_6 is measured without attaching a lens to the lamp assembly and obtained data is shown in TAB.4.

TAB.4

	Upright sided chip (FIGs.9A, 9B)
Luminous Flux	16.1 lm
Area of Cavity Opening	1.44 mm^2
Luminous Emittance	11.2 lm/mm^2

From data in TAB.4, it is confirmed that the enough luminous emittance is obtained even when the side surface of chip is not formed inclined.

A light distribution pattern illustrated in FIG.10 is obtained by a simulation carried out in the following manner: a lamp assembly of a headlight for car use, which employs 16 chips illustrated in FIGs.9A and 9B and an optimized reflector, is supposed to irradiate a light beam ahead. From the light distribution pattern in FIG.10 it is confirmed that a clear cut off is realized when the present chips are employed in the lamp assembly.

[Embodiment 5]

[0047] FIGs.11A and 11B is an example of LED lamps for car use in which chips are arranged.

[0048] An LED device is arranged as a multi-type chip consisting of two chips T_7 mounted on a base. Each chip is constituted by layered GaN films being grown on a SiC substrate. The chip T_7 has an area of 0.9mm by 0.9mm and a height of 0.3mm and emit excitation light with a wavelength of 470nm. The junction down type junctions are selected for the present chips. The side surface of the cavity of the chip T_7 is formed upright. A cavity E_6 has a bottom of 1.1mm by 2.1 mm. Two chips T_7 are arranged in the cavity E_6 where distances between the chip T_7 and the side surface of the cavity E_6, and a distance between two chips T_7 are arranged at 100μm. A silicon resin mixed with a YAG:Ce fluorescent material is filled in the cavity E_6 so as to obtain white light. A thickness or concentration of the fluorescent material (not illustrated in FIGs.11A and 11B) is adjusted so as to obtain color coordinates: X = 0.32 and Y = 0.31. A performance of the LED device illustrated in FIGs.11A and 11B is measured without attaching a lens to the lamp assembly and obtained data is shown in TAB.5.

TAB.5

	Multi-type chip (FIGs.11A, 11B)
Luminous Flux	28.2 lm
Area of Cavity Opening	2.3 mm^2
Luminous Emittance	12.3 lm/mm^2

From data in TAB.5, it is confirmed that the enough luminous emittance is obtained by employing the multi-type chip. This implies that the LED device can be employed as a light source of the headlight for car use, since the enough luminous emittance and a light intensity for the headlight is realized by employing a plurality of LED devices.

As explained above, since light irradiated from the side surfaces of the chip is diverged in the chip as a light beam and shadows of conductive wires such as Au wires can be prevented from projecting ahead, the present invention can provide chips as practical products employable in LED headlights and LED fog lamps. Since some of the side surfaces of the chips and the cavities by the present invention are formed in a straight line, a headlight of a car can be formed such that irradiated light from the headlight is prevented from reaching to a driver in the opposite lane. Although the area of the cavity opening is set less than two times of the maximum area of the light emitting part, a sufficient luminous flux diverging rate can be obtained. In addition, since the angle $\ominus_2$ between the bottom of the cavity and the side surface of the cavity can be set in a range of more than 0°and less than 90°, various types of LED devices for car use can be provided.

Further, since the base of the LED device by the present invention has at least one straight portion, the LED device as a light source is attached to the lamp assembly by its strait portion, the cavity is not fitted at a wrong angle to the lamp assembly. Therefore the straight portion of the base has an effect to prevent from obtaining an undesired light distribution pattern due to a deviation in the attached angle of the base of the LED device to the lamp assembly.

Claims

1. A wavelength conversion element for car use comprising:

   a heat conductive base having a cavity (E);
   one or more chips (T) fitted to said cavity (E); and
   a wavelength conversion part (F), which converts a portion of or the total emitted light from said chips, to visible rays, arranged above said chip; wherein:

   said chip (T) is light emitting semiconductor and comprises at least one active layer which can emit UV or blue light;
   said chip (T) has at least one straight side in its plan view;
   an angle $\ominus_2$ formed between the bottom and the side surface of said cavity is more than 0°and less than 90°;
   said cavity (E) has at least one straight side in its opening; and
   a ratio of the opening of said cavity to the total of areas of said respective chips in the plan view, is set less than three.

2. The wavelength conversion element for car use according to claim 1, wherein: a light extracting part having a refractive index between that of said substrate (A) and that of said wavelength conversion part (F), is formed at the opening side of said cavity (E).

3. The wavelength conversion element for car use according to claim 1 or 2, wherein:

   said base having said cavity (E) has at least one straight side.

4. The wavelength conversion element for car use according to claim 1, wherein:

   a shape of said chip (T) and a horn shape of said cavity (E) in their plan view are formed in parallelograms including a square and a rectangle.

5. The wavelength conversion element for car use according to claim 4, wherein:

   the length of said chip (T) is different from the width of said chip.

6. The wavelength conversion element for car use according to either one of claim 1 or claim 5, wherein:

   said chip is a junction down type chip including a flip chip type chip; and
   an electrode arranged on the bottom of the cavity has a high reflective electrode containing either one of Al, Ag, Rh or Pt.

7. The wavelength conversion element for car use according to either one of claims 1, 5 or 6, wherein:

   portions of one or more of said chip, said substrate and said light extracting part are coated with a high reflective film.

8. The wavelength conversion element for car use according to either one of claims 1, 5 to 7, wherein:

   portions of one or more of said chip, said substrate (A) and said light extracting part (C) are inclined to the opening of said cavity (E) by an acute angle of $\ominus_1$;
   inert gas is filled around said chip; and
   said wavelength conversion part is formed at the opening side of said cavity.

9. The wavelength conversion element for car use according to claim 2, wherein:

   a thickness d of said light extracting part is determined by the following equation: $d = [(\lambda/4) + m(\lambda/2)]/n$ (λ: a wavelength of the emitted light, n: a refractive index of said light extracting part, m: an integer).

10. The wavelength conversion element for car use according to either one of claims 1, 5 to 8, wherein:

said chip employing a conductive substrate is fitted to said base by a junction down type junction;
the electrode arranged on the bottom of said cavity has the high reflective electrode containing either one of Al, Ag, Rh or Pt; and
an electrode at the cavity opening side is arranged outside of the center portion of said wavelength conversion element.

11. The wavelength conversion element for car use according to either one of claims 1, 2, 5 to 8, wherein:

said chip employing the conductive substrate is fitted to said base by the junction down type junction;
the electrode arranged on the bottom of said cavity has the high reflective electrode containing either one of Al, Ag, Rh or Pt;
said light extracting part, which employs a conductive material, is formed on said substrate; and
an electrode formed on said light extracting part is arranged outside of the center portion of said wavelength conversion element so as to control an effect caused by a projected shadow of a conductive wire which is formed on said electrode formed on said light extracting part.

FIG.1A

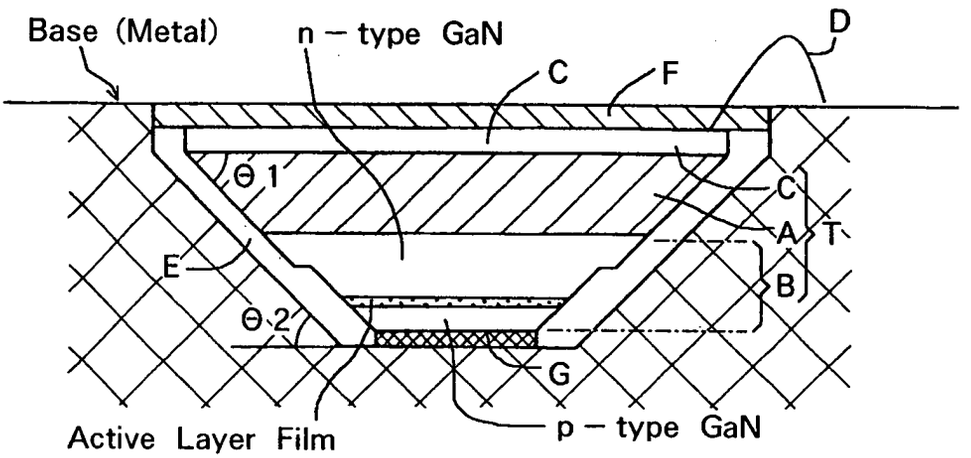


FIG.1B

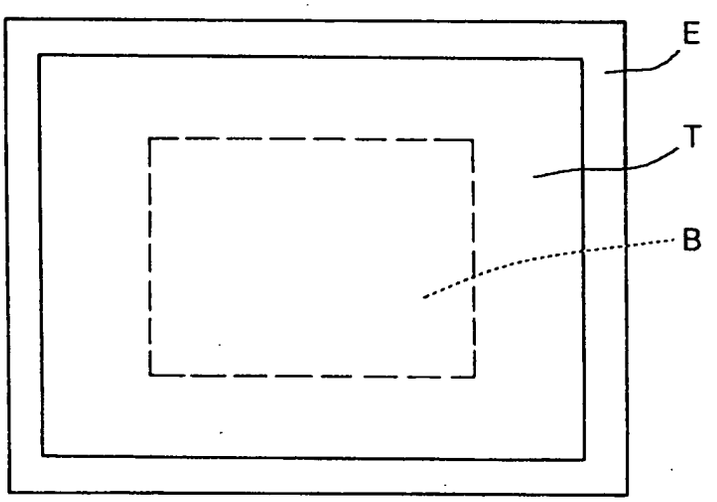


FIG.2

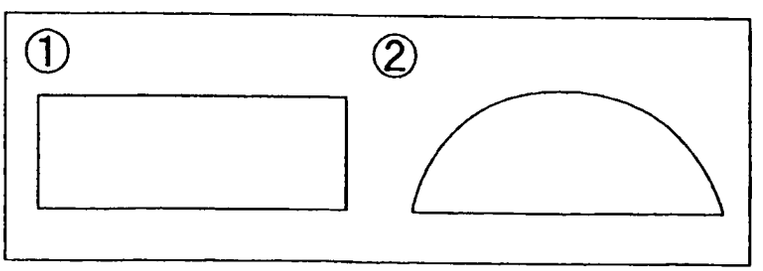


FIG.3A

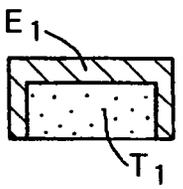


FIG.3B

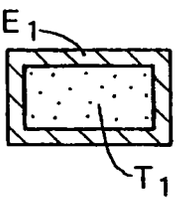


FIG.4A (PRIOR ART)

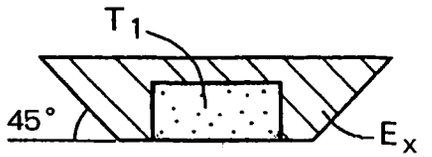


FIG.4B (PRIOR ART)

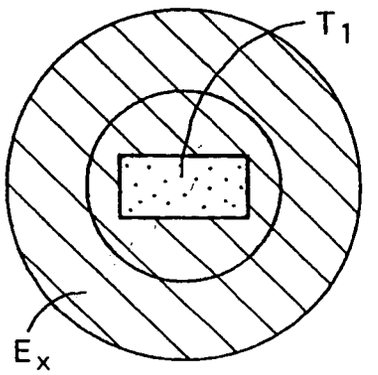


FIG.5A

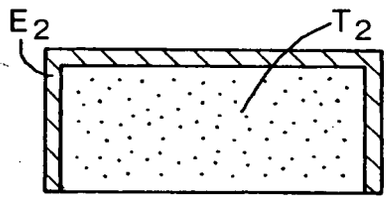


FIG.5B

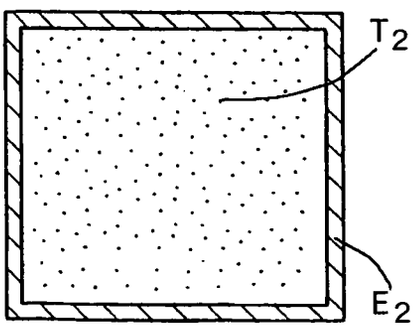


FIG.6A

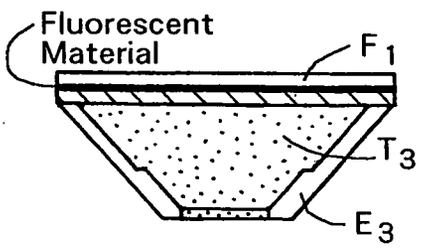


FIG.6B

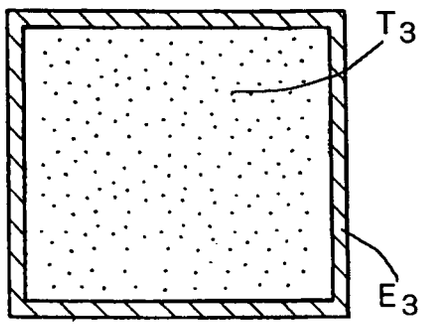


FIG.7A

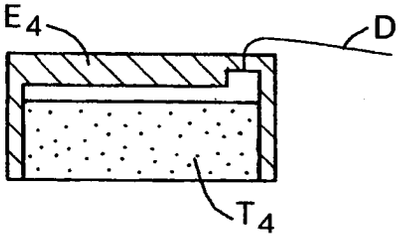


FIG.7B

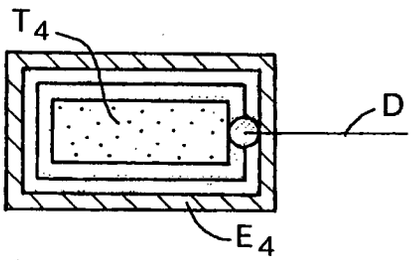


FIG.8A

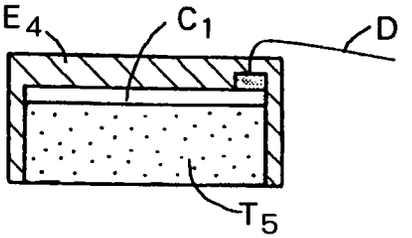


FIG.8B

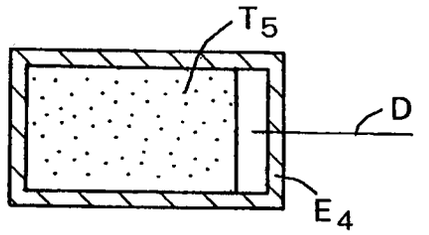


FIG.9A

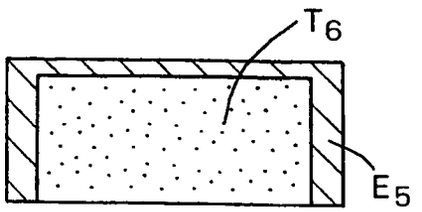


FIG.9B

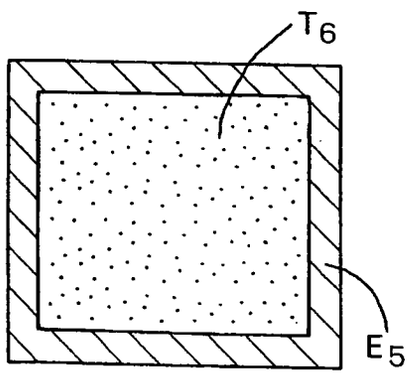


FIG.10

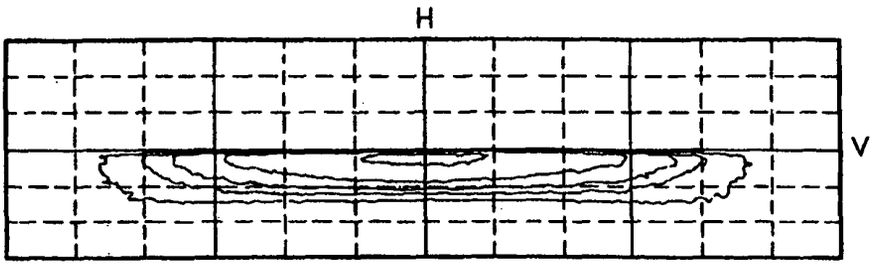


FIG.11A

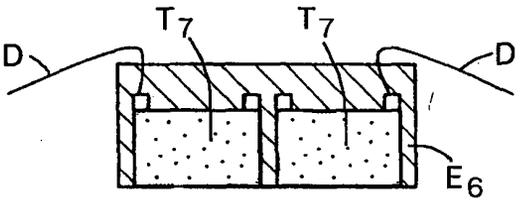


FIG.11B

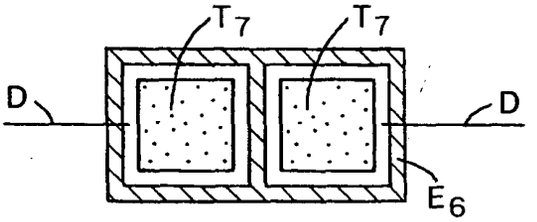


FIG.12 (PRIOR ART)

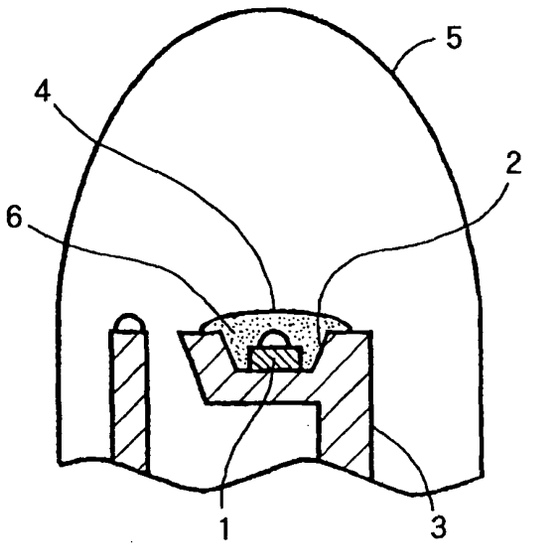


FIG.13 (PRIOR ART)

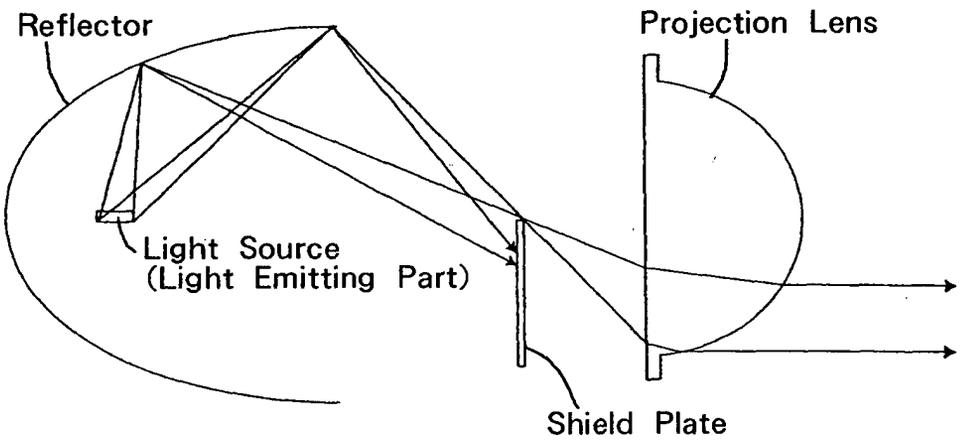
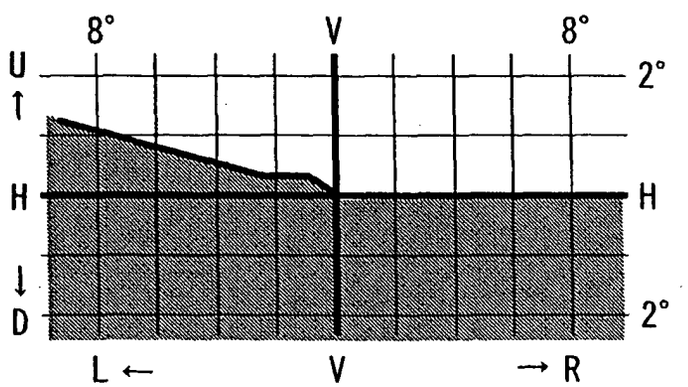


FIG.14



H : Horizontal Line

FIG.15 (PRIOR ART)

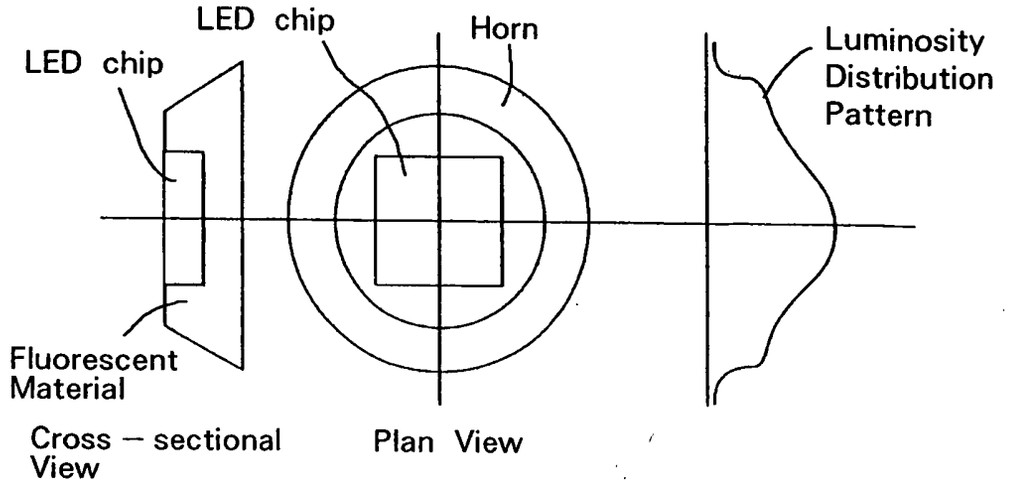


FIG.16 (PRIOR ART)

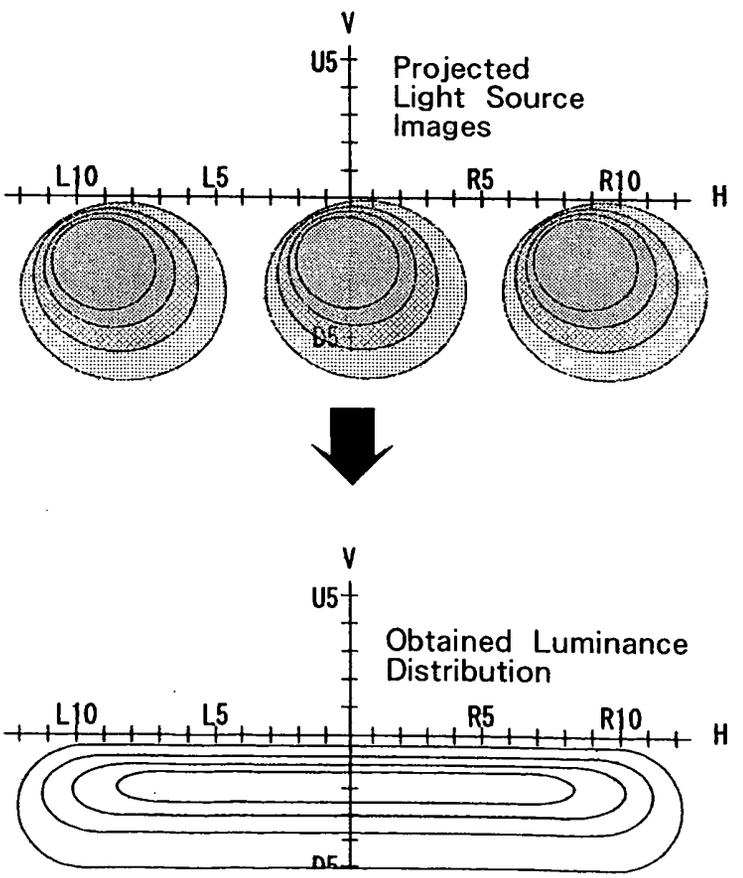


FIG.17

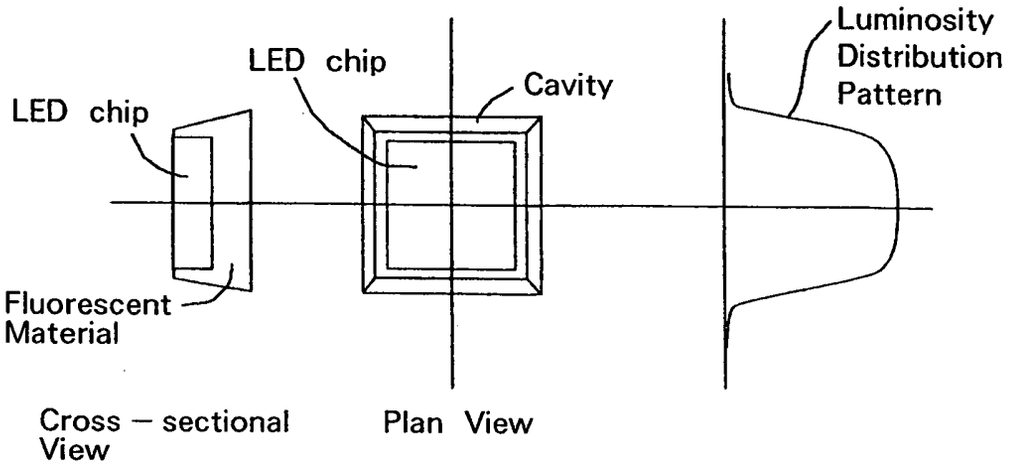
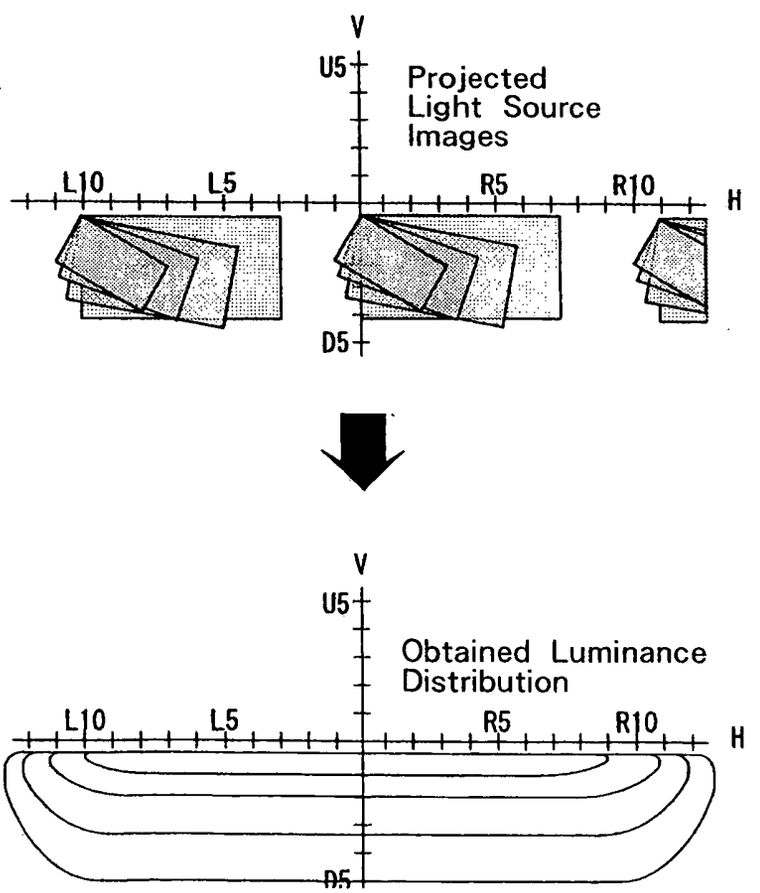

LED chip
LED chip
Cavity
Luminosity Distribution Pattern
Fluorescent Material
Cross – sectional View
Plan View

FIG.18


V
U5
Projected Light Source Images
L10
L5
R5
R10
H
D5
V
U5
Obtained Luminance Distribution
L10
L5
R5
R10
H
D5